DOCUMENT RESUME

ED 063 341 TM 001 359

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TITLE The Use of Formative Evaluation Procedures in the Development of a Mathematics Laboratory.
INSTITUTION Pittsburgh Univ., Pa. Learning Research and Development Center.
PUB DATE Apr 72
NOTE 25p.; Paper presented at the annual meeting of the American Educational Research Association (Chicago, Illinois, April 1972)

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Curriculum Development; Early Childhood Education; Educational Experiments; Educational Objectives; Evaluation Techniques; *Formative Evaluation; *Individualized Curriculum; *Laboratory Procedures; Learning Processes; *Mathematics Instruction; Models; Program Development
IDENTIFIERS Lindvall Cox Model

ABSTRACT

The procedures used in the initial development of a Mathematics Laboratory within the Individually Prescribed Instruction (IPI) Mathematics Program are reported. The thesis of the report is that in the development of educational programs, especially those which are complex, attention should be directed both to the design of the program and the design of its evaluation, both formative and summative. Using the Lindvall-Cox model framework, it is suggested that one product of each phase of the development effort should be a revised "Goals-Plan-Operation-Assessment" outline, with such an outline then being used in the subsequent phase to guide its installation and evaluation. The Evaluation Outline presented contains in a concise form a description of the program at this state of its development. (Author/DB)

ED 063341

THE USE OF FORMATIVE EVALUATION PROCEDURES IN THE DEVELOPMENT OF A MATHEMATICS LABORATORY

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1972

TM 001 359

A paper presented at the Annual Meeting of the American Educational Research Association, Chicago, April 3-7, 1972.

The research reported herein was supported by the Learning Research and Development Center supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare. The opinions expressed in this publication do not necessarily reflect the position or policy of the Office of Education and no official endorsement by the Office of Education should be inferred.

The Use of Formative Evaluation Procedures in the Development of a Mathematics Laboratory[1]

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In his frequently quoted 1963 article, "Course Improvement Through Evaluation," Cronbach (1963) developed the thesis that evaluation can make its most important contribution to the improvement of education when it is used as a basis for program revision rather than for any type of final assessment. Shortly thereafter, Scriven (1967) used the term "formative evaluation" to differentiate the role of evaluation in program development from its "summative" role in the final assessment of a program. Stake (1969) distinguished between these two roles - one providing the information the "program people" want to know and the other what "outsiders" want to know. He states:

> "We can make a non-trivial distinction between formative evaluation for the program developer who is planning ahead and trying to choose the best ingredients, and summative evaluation for anyone who is looking at the program, past or present, and who is trying to find out what it is and what it does." (1969, p. 40)

In attempting to more fully describe these roles of evaluation, a number of persons have proposed models and procedures for the systematic planning and carrying out of a total evaluation program. These models place major emphasis on the integration of evaluation and program development activities. Stufflebeam (1968) describes four cyclic evaluation stages through which a developer could proceed to make necessary

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[1]Appreciation is expressed to Millie K. Sass, who assisted in the implementation of this laboratory.

decisions concerning his program. These evaluation stages are: (1) Context - determine objectives; (2) Input - design procedures; (3) Process - utilize control and refine procedures; (4) Product - judge and react to attainments. Stake (1967) identifies six stages and uses the term "congruence" to relate what is intended to what actually is in operation.

In a somewhat comparable model, but one which is directed more to the process of developing a new educational program, Lindvall and Cox (1970) outline formative evaluation activities that permit the developer to examine each element in the design and operation of the program. They suggest that such an examination will be enhanced if the program is outlined using four categories which: (1) specify the program's Goals; (2) outline a Plan for the achievement of these goals; (3) describe the plan as it should appear in Operation; and (4) specify the Assessment procedures that will be used to measure the achievement of the established goals.

Figure 1 specifies the formative evaluation activities that should be performed in utilizing such an outline in the development of a program. This evaluation focuses on four basic questions:

(1) What goals should the program achieve?

(2) What is the plan for achieving these goals?

(3) Does the operating plan represent a true implementation of the plan?

(4) Does the operating plan achieve the desired goals?

The two-way loops below each program category describe the necessary procedures that should be performed in the answering of these questions.

As these loops illustrate, this formative evaluation process must examine how each step is dependent upon the step or steps that precede it and how each influences those which follow.

Purpose of Study

This study, performed within the same context in which the Lindvall-Cox model was developed, the Individually Prescribed Instruction (IPI) Project of the Learning Research and Development Center at the University of Pittsburgh, is a description of the development process, when formative evaluation is taken quite seriously, in the installation of a new program component. Specifically, this study is a report of the procedures used in the initial development of a Mathematics Laboratory within the IPI Mathematics Program.

The thesis of this paper is that in the development of educational programs, especially those which are complex, attention should be directed both to the design of the program and the design of its evaluation - both formative and summative. That is, in addition to testing and refining the operating plan, the developer should, at the same time, be defining procedures and strategies which will provide him in the future with valid information as to when the operation reflects the plan and the degree of attainment of the program's goals.

Using the Lindvall-Cox framework, this suggests that one product of each phase of the development effort should be a revised "Goals-Plan-Operation-Assessment" outline. Such an outline would then be used in the subsequent phase to guide its installation and evaluation.

The characteristics of the laboratory, as tested in this study, will be presented in the following description of the steps followed in its initial tryout in a classroom. This paper will primarily focus on: (1) the methodology used to formulate the evaluation outline prior to the tryout; (2) a description and evaluation of the tryout; and (3) the formulation of the "Goals-Plan-Operation-Assessment" outline for the next development phase.

Development - Phase I

Specification of Goals and Development of Plan

The specific goals of the lab were derived from an assessment of the existing IPI Math Program and a consideration of the desired additional learning experiences that might be provided by such a learning setting. These goals (see Figure 2), stated in terms of observable pupil behavior, describe the kinds of learning experiences which were viewed at this time to be the ones a pupil should have when the lab is functioning in final form. A plan to accomplish these goals was then defined.

This initial plan is based on the best judgement of members of the development staff, who make use of all available sources of knowledge concerning what can be expected to be effective in such a program. The above involves such things as searching the relevant literature, interviewing teachers and other practitioners, and drawing on the past experiences of the staff itself.

The elements of the Phase I Plan are listed in the right hand columns of Figure 2, under the headings: Instructional Objectives,

Pupil Evaluation Procedures, Instructional Activities, Classroom Management Procedures, Teacher Activities, and Pupil Activities. The initial evaluation of this plan was carried out through logical analysis of the relationship of each element in the plan to one of the goals of the lab. That is, concerning each element, the question was raised, "Does this have promise for helping to achieve one or more of the program's goals?"

In the model employed in the present study, this planning is taken through several phases of a "plan-operation-assessment" cycle. Phase I involves a limited tryout and assessment of the initial plan. This phase may be compared with the task of the person who is developing a unit in a programmed textbook when he tries out his initial program with only one or two students. The purpose is to get ideas that will be useful in the further development of his first draft. The information used by the programmer is obtained by watching the pupil as he studies the program, by studying his responses, and by interviewing the pupil. In applying a comparable procedure in the development of this lab, the initial plan is tried out with one or two groups of students, the operation is closely observed, pupil activities and verbal responses are noted, and the teacher is interviewed. This type of informal, but highly informative, assessment information is then used in revising the plan for Phase II. This initial procedure was described earlier as an extension of the Lindvall-Cox Model, in that it calls for carrying out the "goals-plan-operation-assessment" cycle at several successive stages of program development. How this close observation of the first tryout of this initial plan was actually carried out is described in the following section.

Operation - Phase I

The setting for the Phase I implementation was in one first grade class in an IPI experimental school during the Spring of 1971. The laboratory was contained in the classroom and pupils were assigned to it during their regular mathematics period. In order to gain maximum information from this tryout, two project personnel managed the laboratory in place of the regular teacher - one acting as the "teacher," the other as an "observer." The math content taught in this tryout was limited to activities in Beginning Linear Measurement, a unit in which the pupils had not had previous formal instruction. (See Figure 3 for objectives of this unit).

The tryout setting permitted the assignment of pupils to the laboratory in groups of three pupils each day. The first session for each group was conducted by a Project Staff member. In this session, the pupils were told how to use the lessons, where to get materials, and how to record results in their notebooks. They then worked through one of the lessons under the supervision of this person. They were directed to estimate before they measured and to check the accuracy of each measurement by replication or by requesting another pupil to measure the same object and to compare their results. In addition, the pupils were directed not to ask the teacher for help until they had requested assistance from another member of the lab.

The lab activities were presented on laminated cards, using pictures and written instructions involving a vocabulary thought to be appropriate for this age pupil. These activities placed the pupil in situations in which he could learn the measurement outcomes of the unit, as well as offer him a degree of choice in what he was to measure.

Figure 4 is an example of these cards. This is one of several activities in which the pupil uses individual "inch" and "foot" rods to measure in preparation for the use of a standard ruler. The purpose of this lesson is to show that the length of an object can be stated in more than one way, as well as affording the opportunity to "discover" that 12 inches is equivalent to one foot.

The same activity was given to each member of the three-pupil group. Each was reminded to read the card and to ask help of his "neighbor" if he needed assistance and to ask the teacher only as a last resort. As a "rule-of-thumb," a pupil was refused help two times on a given problem before the teacher intervened. The three-pupil-per-day assignment made it possible to revise a lesson on the basis of observed problems and then use the revised lesson with the next day's group. When all pupils had completed one "cycle," the next appropriate activity in the sequence was studied. Time permitted only five of such "cycles" in the ten weeks. In the third through fifth cycles, members of the groups received different cards in order to test more lessons.

This tryout of the effectiveness of lesson materials depended upon the pupils acquiring and maintaining a degree of independence from the teacher. In the initial cycles of this tryout, teacher influence was directed to shaping this behavior through, (1) refusal to answer questions which the teacher felt could be answered by the pupil or by others in the group, and (2) by verbal rewards for self-directed activity. Also, attention was given to the problem of how the teacher could best interact with pupils to promote discovery and exploration, in addition to that

provided by the lessons. The effectiveness of guiding questions and brief demonstrations was explored to develop this behavior.

In the fourth and fifth cycles the regular classroom teacher managed and controlled some lab sessions in addition to her regular class individualized instruction. Prior to each class period, she was directed to perform certain interactions with the lab pupils. The observer noted these interactions and their effect on pupils after she had left. The teacher also provided important information missed by the observers, due no doubt to her familiarity with the pupils.

Evaluation of Operation - Phase I

A key focus of formative evaluation is in examining a program when it is first placed in operation. Here the intent is both to determine the extent to which the planned program is actually implemented and to assess the extent to which program goals are being approximated. In evaluating the operation of the laboratory, an observer was stationed in the room throughout the tryout. He recorded in diary form the activities of each day. After each session, the project personnel met and discussed the days experiences. Those events which were thought to be pertinent to the program's development and evaluation were noted. No formal observation instruments were used.

The results of this evaluation of the operation in the Phase I Cycle can best be discussed in relation to each category of the plan.

Instructional Objectives. The performance objectives, stated in terms of the observable pupil behavior were those included in the beginning linear measurement units of the IPI Continuum. They were found to be

necessary in the design of the lesson activities so that the measuring experiences would focus on the desired pupil outcomes.

Pupil Evaluation Procedures. The plan elements under this category reflect "self-evaluation" components which are thought to be required when the pupil was "self-managing" his work in the lab. Since these elements were not implemented in this tryout, their evaluation cannot be made at this time.

Instructional Activities. The type of changes made in the activity cards were too many to enumerate in this paper. The modifications were mainly in format and appearance of the card, type and wording of questions, and general organization. It was found that undue novelty and complexity of operations should be avoided, at least for this age pupil (6-7 years). Examples of a process or a diagram of recording procedures were useful to some pupils. Questions should be simple and prominently arranged on the card. Numbering of steps or questions should be avoided, unless they are useful in the demonstration of a multiple-step process. Recording of results was facilitated when an established format was used in the notebooks rather than blank paper.

Classroom Management Procedures. The lab model was designed for an in-classroom operation. One concern in this tryout was whether the teacher, with her other classroom duties, would have the time to make her necessary interactions with pupils. An additional one was the possibility that the pupil activity generated by this setting would be distracting to other pupils. It appears from this limited tryout that the teacher could manage these pupils, as well as her "regular" instructional duties. The activity of the pupils was not as distracting to others and in some cases

proved to be a "non-planned" productive experience for lab-pupils to interact with other students on measurement tasks.

Teacher Classroom Activities. Once the pupils were oriented to the laboratory procedures and the "rule" ("Ask someone in the lab if you need help"), verbal reinforcement by the teacher appeared to be sufficient to sustain these behaviors in most of the pupils. The teacher "traveling model" which influenced the most productive pupil behavior was: (1) observation at the beginning of the period; (2) a ten to fifteen minute wait; then (3) short (1 minute or less) interactions through the remainder of the period. These interactions were generally teacher-initiated questions. It was noted that the teacher-initiated interactions, at times, interrupted productive pupil activity (as assumed by the observer). This suggests that the teacher should be prudent in interrupting pupils for these interactions.

Pupil Classroom Activities. By the fourth and fifth cycles (the fourth and fifth time in the lab), a majority of the pupils had achieved a measure of self-directed behavior. This was evidenced by sustained attempts to read the activity cards, helping behavior, and proper use of the materials as suggested by the lessons. Checking behavior, however, was not performed by a majority of the pupils without constant reminders. Pupils did enjoy selecting their own objects to measure.

Non-Planned Aspects of the Operation. Once a program is installed in such an in-context setting, many non-planned behaviors do occur. Some appear to be significant enough to be considered for incorporation to the evolving plan of this lab. One significant contribution was the ease to which the teacher, in her interactions with pupils, could relate math skills

to a measurement task. Some of these first grade pupils were quite amazed that their knowledge of beginning arithmetic operations could be applied to their measuring problems.

Assessment

The ultimate achievement of a program's goals will be determined by some final assessment. However, during development, the operating plan must be continually assessed as to the extent to which its elements are contributing to this achievement. As with the evaluation in the operation stage described above, the assessment stage in Phase I is carried out so as to provide information on the achievement of program goals, as well as contribute to the further refinement of the plan and operation.

Goal 1 - The pupil learns through active involvement, both independently and with other pupils.

All pupils were quite active in the performance of their assigned measuring tasks. They recorded their estimates and measurements in their notebooks and some pupils, at times, stated the number of units they were "off" in their estimates. The "free" environment designed in this tryout resulted in many instances of "pupil-arranged" cooperative behavior. This included assisting each other in measuring, reading lessons and recording in notebooks. At times, a pupil could be observed just watching another pupil performing a task - these observations interspersed with a comment or question.

Goal 2 - The pupil selects activities for which he determines that he has the necessary prerequisites.

Plan elements were not implemented to achieve this goal, in that

all activities were assigned to pupils to test lesson design procedures. However, the experience of this tryout suggests that for pupils to self-select activities for which they will have a meaningful learning experience, some provision must be made for them to evaluate their own competencies.

Goal 3 - The pupil formulates new examplars of the concept.

This objective encompasses behaviors that involve the application or extension of an activity to new instances defined by the pupil (and not specified by the lesson itself). Each activity card provided the opportunity for the performance of this behavior, by suggesting to the pupil that he could measure objects of his choice in the room. The pupils appeared to enjoy this time and some would spend the remaining time in the period measuring, many times striving to locate something unique to measure. However, the teacher's influence is needed to guide some pupils in productively using this opportunity to apply or extend their learning.

Goal 4 - The pupil formulates and tests hypotheses.

A defining characteristic of laboratory learning is that the pupil learns through the process of formulating a hypothesis and subsequently testing this conjecture using concrete materials or math skills. It is thought that the success of this method will vary as to abilities of the pupil, as well as to the topic studied. Therefore, the degree of sophistication in hypothesis formation and testing expected for first-graders would, no doubt, be different from that desired for sixth-grade pupils.

In this tryout, pupils did exhibit some low level hypothesis formulation and testing behaviors. Practically, all pupils by the end of the ten weeks would estimate the measurement of an object before they

measured. In addition, many of the activities presented measurement situations which required the pupil to formulate a "method of attack" to arrive at the solution. "Without moving the desk, can you tell if it can be moved through the doorway?" This could be considered a hypothesis in the form, "I can find out if the desk fits through the door if I cut a piece of string the same size as the desk and compare its length to the width of the door."

Other than the evidence of estimation, no other data was collected on the degree of attainment of this goal. It can only be assumed that in the act of solving problems similar to the one described above, the child may have proceeded in this fashion. It is suspected that the consistent use of this process by pupils can best be developed through the experiences included in the activity cards, as well as teacher-pupil interactions directed to shaping this type of behavior.

Goal 5 - The pupil monitors and evaluates his own progress.

Plan elements were not implemented to achieve this goal. However, in consultation with the teachers, they were of the opinion that the development of this behavior might be quite difficult for primary age children. This goal, then, should be modified to include only the recording of progress by pupils; the monitoring to be a task of the teacher.

Goal 6 - The pupil selects activities of interest to him.

The plan elements providing for pupil self-selection of activity cards were not implemented to achieve this goal. Pupils did have the opportunity to select their own objects to measure, as described previously. Both this Goal and Goal 2 reflect selection behavior, so they might well be combined.

Goal 7 - The pupil acquires skills and comprehension by carrying out meaningful activities and experiments.

The instructional effectiveness of the laboratory in this ten-week tryout was measured by the administration of a criterion-referenced test on the objectives of the unit. Using a posttest-only design, this test was administered to the lab-class and a companion first-grade which had not received any formal measurement instruction.

The results of this test are summarized in Figure 5. This information showed that the lab activities and procedures did have an effect on some pupils in at least three of the six pupil outcomes. It also suggests that Objective 1 (makes gross comparisons on the basis of length, i.e., longest, shortest) is probably taught elsewhere in the school program and could possibly be eliminated from the measurement curriculum. The similar percentages of pupils mastering objectives 4 and 5 in the two groups appears to show that the materials and procedures were not effective in increasing the competencies of the lab group. The low percentage scores on the other objectives, which did show a differential effect of lab activities, were somewhat expected since time did not permit pupils to use all of the activities designed to teach these objectives.

It must be stressed that the administration of this type of test, at this point in development, has essentially no implications for the eventual worth of the program. This information, as well as the previous discussion of the effect of this tryout on the other goals, has value only in improving this development effort.

Results

This study described the development and application of a formative evaluation procedure in the initial design of a mathematics laboratory for young children. Since the refinement of this design involves a recycling of steps in successive "phases of revision," the results of the Phase I activities can best be represented by the Goals and Plan for Phase II. These are specified in the outline for Phase II, as formulated at this point in the development and evaluation process (see Figure 6).

The first column lists the "Goals" for the program in Phase II. It will be noted that these goals do differ slightly from those proposed at the beginning of the project. Some have been combined and others reworded for clarity. Several additional goals have been proposed which define outcomes which are viewed at this time as being relevant to the rationale and management of a laboratory in relation to the IPI Math Program.

The "Plan" elements define the lab at this stage of development In comparison with the Phase I plan, some elements have remained the same and others rephrased. In addition, new elements have been added as a result of the experience in this tryout. What is not reflected here is the relative importance of some of these to the achievement of their associated goals.

The "Operations" column defines the observable characteristics of each element in the Plan. From this listing, the observation schedules will be prepared to monitor the Phase II implementation; this monitoring, of course, is fundamental in the formative evaluation of a development effort.

The "Assessment" column lists the general methods to be used to measure the degree to which the operating plan results in the achievement of the stated goals. These methods are only descriptive of what will be done or used in the on-going assessment.

This Evaluation Outline presents in concise form a description of the program at this stage of its development. The operating plan will be more adequately described in teacher manuals and observation schedules. Some of the assessment instruments are presently defined, while others will be devised during the next development phase when characteristics of goal achievement can be more adequately defined.

This paper proposes a model of development which places emphasis on the design of a formative evaluation, as well as use of this information for program improvement. In this description of the Phase I tryout and the design of the laboratory for the next development phase, much of the information gleaned was quite subjective in nature. But, as development proceeds, more empirical data will be collected which can be used to refine the program so a reliable operational plan results in the achievement of the program's goals.

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Figure 1

THE MONITORING ACTIVITIES OF FORMATIVE EVALUATION

(Lindvall and Cox, P. 5)

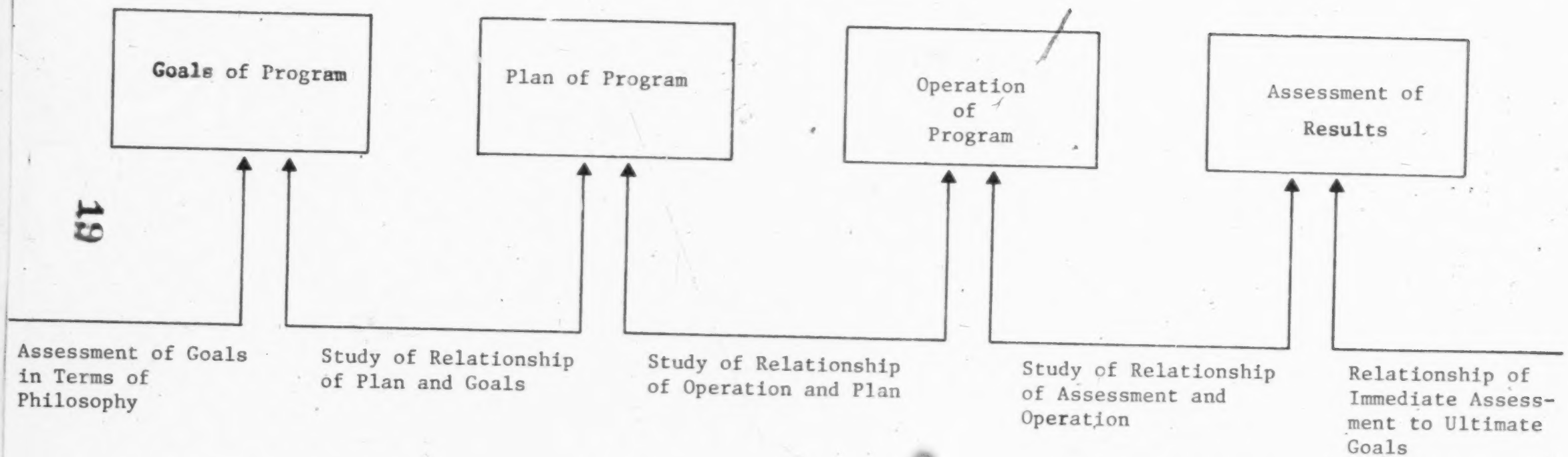

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FIGURE 2: MATH LABORATORY EVALUATION OUTLINE
Phase I

GOALS

The Pupil:

1. Learns through active involvement, both individually and with other pupils.

2. Selects activities for which he determines that he has the necessary prerequisites.

3. Formulates new exemplars of the concept.

4. Formulates and tests hypothesis.

5. Monitors and evaluates his own progress.

6. Selects activities of interest to him.

7. Acquires skills and comprehension by carrying out meaningful activities and experiments.

PLAN

INSTRUCTIONAL OBJECTIVES that:

a. Specify the desired behaviors (Goal 1,2,5,7).

b. Define Pre-requisite abilities (Goal 2)

c. Guide the preparation of laboratory activities (Goal 1,2,7).

PUPIL EVALUATION PROCEDURES that:

a. Give pupils information to select meaningful activities (Goal 2).

b. Give pupils feedback as to their success in the activities (Goals 3,4,5,7).

c. Provide the pupil with an external criterion of progress (Goal 5,7).

INSTRUCTIONAL ACTIVITIES that:

a. Give the necessary experiences for mastery of the desired behaviors (Goal 1,7).

b. Teach the desired behaviors through varied settings and approaches (Goal 1,3,4,6,7).

c. Provide guidance for the selection of activities (Goal 2,6).

d. Pose open-ended questions (Goal 1,3,4,7).

e. Require manipulation and experimentation (Goal 1,3,4,7).

f. Are appealing and interesting to the pupil (Goal 1,2,6).

CLASSROOM MANAGEMENT PROCEDURES that:

a. Permit pupils to keep their own records of their progress (Goal 5).

b. Allow pupils to self-select activities for study (Goal 2,5,6).

c. Permit several pupils to work as a team on activity (Goal 1,3,4,7).

d. Permit most laboratory activities to take place in the classroom (Goal 1,2).

TEACHER CLASSROOM ACTIVITIES that:

a. Provide help when pupil needs it (Goal 1,2,3,4,5,7).

b. Provide the pupil with additional insights into the activity (Goal 1,3,4,7).

c. Permit the teacher to spend time with the pupil or group of pupils (Goal 1,3,4,5).

d. Assist pupils in monitoring and recording their experiences (Goal 5).

PUPIL CLASSROOM ACTIVITIES that:

a. Permit help and assistance from other pupils (Goal 1,2,7).

b. Permit pupils to select the laboratory as an alternative to skills prescription (Goal 2,5,6,7).

Figure 3

UNIT OBJECTIVES

The Pupil:

1. Uses terms, longer(est), taller(est), shorter(est) to make simple gross comparisons on the basis of length.
2. States there are 12 inches in one foot.
3. States there are 3 feet in one yard.
4. States there are 36 inches in one yard.
5. Uses 12-inch ruler to measure length of objects less than 12 inches long to nearest inch (1/2-inch ruler markings).
6. Measures a given length less than 24 inches and states measurement in "inches" and "feet and inches."
7. Draws line of a given length (less than 24 inches) with a 12-inch ruler.

Figure 4

Activity Card

You will need: inch

L M 5b

foot

How long is 5 of your hand spans?

Measure using inch

Measure using both

inch

foot

Measure some other things two ways.

(The actual pupil cards are colored and laminated in plastic.)

Figure 5

PERCENT OF PUPILS MASTERING EACH MEASUREMENT
OBJECTIVE IN THE LAB AND
NON-LAB GROUPS

Objective Number	Lab Group N=23	Non-Lab N=23
1	100%	100%
2	77	52
3	37	27
4	39	37
5	63	63
6	30	17
7	56	35

FIGURE 6 MATH LABORATORY EVALUATION OUTLINE
Phase II

GOALS

The Pupil:

1. Acquires comprehension of math skills.

2. Has the opportunity for discovery by carrying out meaningful activities and experiments.

3. Learns through active involvement, both independently and with other pupils.

4. Uses other skills, e.g., writing, reading, art, estimation, checking.

5. Has opportunity to select the laboratory as an alternative to other math activities, as well as the tasks he performs.

6. Assists other pupils in their laboratory learning.

7. With other pupils in the laboratory, manages his work with minimum direction from teacher.

PLAN

INSTRUCTIONAL OBJECTIVES that:

a. Specify the desired behaviors (Goal 1, 2, 3, 11)

b. define prerequisite abilities (Goal 1, 5, 11)

c. guide the preparation of laboratory activities (Goal 1, 2, 3)

EVALUATION PROCEDURES that:

a. Give pupils information to select meaningful activities (Goal 5, 7, 10)

b. give pupils feedback as to performance (Goal 1, 2, 3, 4, 5, 9, 10)

c. provide the pupil with an external criterion of progress (Goal 1)

INSTRUCTIONAL ACTIVITIES that:

a. Teach the desired behaviors through varied settings and approaches (Goal 1, 2, 3, 4, 6, 8, 9, 10)

b. provide sufficient experience for the pupil to achieve the desired outcomes (Goal 1, 2, 3)

c. pose questions that would promote exploration (Goal 2, 8, 9, 10)

d. suggest associated activities (Goal 1, 2, 4, 6, 9, 10)

e. require manipulation and experimentation (Goal 1, 2, 3, 8, 10)

f. are appealing and interesting to pupils (Goal 1, 2, 3, 4, 5, 7, 9)

g. are appropriate for the age of pupil (Goal 1, 2, 4, 7)

h. allow pupils to record their results (Goal 2, 11)

OPERATION

INSTRUCTIONAL OBJECTIVES that:

a. Can be used by lesson writers, test developers, and teachers without ambiguity.

b. are in prerequisite order as evidenced by pupil progress.

c. permit lesson writers to design laboratory activities from which the pupil can learn the desired outcome.

EVALUATION PROCEDURES:

a. Are used by the pupil to select activities which are appropriate for his present abilities.

b. provide the pupil with information that is meaningful to him.

c. provide a valid assessment of his laboratory work.

The INSTRUCTIONAL ACTIVITIES:

a. Permit the pupil to learn the behavior both independently and with other pupils.

b. are available to pupil that vary in approach.

c. have questions that do lead to exploratory behavior.

d. do lead to pupils applying skills to related activities.

e. are such that pupils do use and experiment with concrete objects.

f. are such that pupils are interested in lab activities.

g. are such that there are different lessons on the same objective for differing abilities.

h. are such that pupil do record their results.

ASSESSMENT

Goal 1 (Methods of Assessment)

a. Comparison of September and June results on curriculum test.

b. inspection of pupil notebooks.

c. interviews with pupils.

Goal 2 (Methods of Assessment)

a. Inspection of pupil notebooks.

b. regular class observation.

Goal 3 (Methods of Assessment)

a. Regular class observation.

b. number of peer-peer interactions.

Goal 4 (Methods of Assessment)

a. Inspection of notebooks.

b. observation of use of reading skills.

c. observation of use of estimation and checking.

Goal 5 (Methods of Assessment)

a. Inspect pupil flow chart on number of lab selections

b. interviews with teachers.

c. observation of entrance into lab behavior.

Goal 6 (Methods of Assessment)

a. Observation of individual helping behavior.

Goal 7 (Methods of Assessment)

a. Observation of pupil management behavior.

b. data on type of teacher interactions with lab pupils.

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8. Verifies his results through estimation, replication, and evaluation with other pupils.

9. Applies skills learned to other class situations.

10. Formulates new exemplars of the activity and tests self-devised hypotheses using learned skills and concepts.

11. Records the results of his study and keeps a record of his progress.

MANAGEMENT PROCEDURES that:

a. Permit pupils to select laboratory as a setting for study (Goal 5)

b. provide pupils direction for selection of activities (Goal 5, 7, 11)

c. permit several pupils to work together (Goal 2, 3, 6, 7, 8)

d. permit most activities to take place in classroom (Goal 5, 6, 7)

e. provide each pupil with a notebook (Goal 11)

TEACHER CLASSROOM ACTIVITIES that:

a. Develop in the pupil self-direction competencies (Goal 3, 5, 7, 10, 11)

b. react to individual differences in pupils (Goals 1 - 11)

c. Provide the pupil with additional insights into a topic in an non-directive manner (Goals 1, 2, 9, 10)

d. relate other math concepts to the pupils task at hand (Goal 1, 2, 4, 9, 10)

e. permit the teacher to interact with a pupil or groups (Goals 1, 2, 3, 11)

f. describe reinforcement contingencies (Goal 1 - 11)

PUPIL CLASSROOM ACTIVITIES that:

a. Encourage peer interactions (Goal 3, 6, 7, 8)

b. allow a pupil to make decisions as to what he will study (Goal 1, 2, 5, 9, 10)

c. permit pupil access to materials when needed (Goals 1, 2, 3, 7, 9, 10)

MANAGEMENT PROCEDURES are such that:

a. Pupils select the laboratory.

b. pupils are given direction for selection of lab work.

c. pupils work together.

d. most lab work is in classroom.

e. pupils record results in notebook.

TEACHER CLASSROOM ACTIVITIES are such that:

a. Teachers use various techniques to develop self-direction competencies.

b. teacher takes into account individual differences in pupils.

c. teachers do provide pupils with additional insights into their lab task.

d. teacher does relate math concepts to pupil's lab task.

e. the teacher spends some class time with lab pupils.

f. teachers use appropriate positive reinforcement.

PUPIL CLASSROOM ACTIVITIES are such that:

a. Pupils consult and assist each other.

b. pupils largely select their own activities for study.

c. pupils secure needed materials.

Goal 8 (Methods of Assessment)

a. Inspection of notebooks.

b. observation of pupils.

Goal 9 (Methods of Assessment)

a. Observation of pupils.

Goal 10 (Methods of Assessment)

a. Inspection of notebooks.

b. observation of pupils.

Goal 11 (Methods of Assessment)

a. Inspection of notebooks and progress chart.